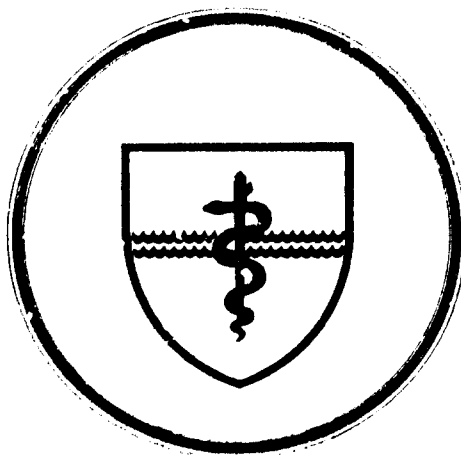


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# NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

SUBMARINE BASE, GROTON, CONN.



MEMORANDUM REPORT 83-3

ANTHROPOMETRIC INDICES  
AMONG U.S. NAVY DIVERS

by

M. L. Dembert and L. W. Mooney  
with  
J. F. Jekel

JUN 21 1983

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Naval Medical Research and Development Command  
Research Work Unit MR00001.01-5078

and partly supported

by a grant from United Technologies Corporation to Yale

Released by:

William C. Milroy, CAPT, MC, USN  
Commanding Officer  
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## SUMMARY PAGE

### THE PROBLEM

Only one large investigation of U.S. Navy diver anthropometry has been published to date. Additional data on anthropometric indices would provide a reference data bank which would assist in the resolution of operational, engineering and medical problems confronting Navy divers.

### THE FINDINGS

Eighteen anthropometric indices obtained during the Longitudinal Health Survey have been analyzed from a cohort of 194 divers. These divers represent the spectrum of naval diving programs. Analysis was performed at two levels. First, statistics on the total cohort were computed. Second, the cohort was divided into two age strata which were felt to correspond to two levels of diving activity: very active and somewhat active. Statistics obtained for each index were fairly similar between strata.

### APPLICATION

Knowledge of diver anthropometry enables this information to be applied to the design of naval diving suits and equipment, to research into diver performance and human factors research, to be incorporated into epidemiologic studies of diver health, and to contribute toward the periodic evaluation of physical standards for military diving personnel.

### ADMINISTRATIVE INFORMATION

The initial data analysis of this work was supported by the Naval Medical Command, Naval Medical Research and Development Command Work Unit No. MR00001.01-5078. Subsequent analyses and the completion of the manuscript were supported by a grant from the United Technologies Corporation to Yale while the principal investigator (MLD) was a resident in preventive medicine at the Yale University School of Medicine.

The manuscript was submitted for review on 23 May 1983 and approved for publication on 8 June 1983. It has been designated as NSMRL Memo Rpt. 83-3.

Published by the Naval Submarine Medical Research Lab.

# ABSTRACT

Anthropometric data obtained from 194 U.S. Navy divers who participated in the Longitudinal Health Survey were analyzed with descriptive statistics. Eighteen indices were examined, and the analysis was presented in two parts for each index. First, the mean value, its standard deviation, and percentiles were computed for the entire cohort. Second, the cohort was divided into two age strata, 20-30 years old and 31-42 years old. Within each stratum, the mean value, its standard deviation, and the range were calculated. When added to other published findings on U.S. Navy divers, these data have application as a reference source for personnel working in diving suit and equipment design, diving operations, human factors research, diving medicine, and epidemiology.

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## INTRODUCTION

Military anthropometry has been extensively investigated among U.S. Army and Marine Corps male and female personnel (1-2). It has also been incorporated into longitudinal studies of Naval aviators (3). However, military divers have been little characterized in terms of anthropometric indices.

From 1972-1978, the Naval Submarine Medical Research Laboratory conducted the initial phase of a Longitudinal Health Survey on a cohort of 197 U.S. Navy divers. The survey collected physical and historical information on fourteen multiphasic health profiles obtained during the initial examination of each diver. Anthropometry was one of these profiles, and relevant data were collected for several reasons. First, a review of the literature showed that there had been only one large study of U.S. Navy diver anthropometrics published to date (4). Other reports on associations between diver morbidity and physical characteristics considered few measures of body build or stature (5-6). Second, additional information on the characteristics of diver build could be incorporated into new designs for diving suits. Proper design is important for effective external temperature regulation of the body and it allows for better mobility and dexterity in performance. Third, information on diver build allows for the design of consoles in submersible vehicles as well as for the design of controls on diving equipment carried by the diver, e.g., regulator, gas mixture controls, straps and buckles. Finally, data collected on diver anthropometrics can be used in future epidemiologic studies of diver health that examine associations between anthropometry and risk for chronic diseases (e.g., coronary artery disease and diabetes mellitus), acute morbidity (e.g., musculoskeletal disorders such as low back pain), and diving-related problems (e.g., decompression sickness) (7).

## METHODS

The purpose and design of the Longitudinal Health Survey have been described elsewhere (8-9). The initial findings and descriptive statistics on the cohort have been recently reported (10). This cohort was a nonrandom sample, as all who volunteered were accepted into the study. The cohort was nevertheless considered representative of the total Navy diving population, based on its distribution by rank, rate, and paygrade.

The eighteen anthropometric measures were taken on the advice of Mr. Robert White of the U.S. Army Natick Research and Development Command, Natick, Mass. All measurements were taken by the same examiner, who was trained by Mr. White. Weight was recorded on spring scales. Circumferences were measured with Keuffel and Esser Wyteface tape. Linear parameters were measured with GPM anthropometers, except for the foot length, which was measured in a foot measuring box. Skinfold thickness determinations were made

with Lange skinfold calipers and were not obtained on all divers.

The individual method for each measurement was previously described (4,8-9), but this information is repeated here for the purpose of completeness of the report. Methods are combined with respective results and presented in Tables 1 through 18.

The original data for this study were collected during the Longitudinal Health Survey. The data for the present study were recoded and entered into the computer at Yale Computer Center, New Haven, Conn. All analyses were performed using programs from the Statistical Analysis System (11).

Upon the advice of Dr. Joseph Knapik of the Exercise Physiology Section of the U.S. Army Research Institute of Environmental Medicine, Natick, Mass., the mean, standard deviation and 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles were computed for each measurement on the total cohort. This cohort was also broken into two age group strata for further analysis: 20-30, and 31-42. It was intuitively felt that more active divers would be in the former age interval, while less active divers would comprise the latter interval. This is supported by the findings of Berghage et al. (12), who found that approximately 69% of the active Navy divers in their survey were 30 years of age or younger. Also, the use of age intervals greater than five years (e.g., ten) is commonly used in descriptive epidemiologic studies and is predicated upon the available sample size. Stratification of the present cohort into smaller size age groups (e.g., five-year intervals) could obscure interpretation of the data because of the inherent large variability of values within such strata. Using two age strata, the mean, standard deviation, and range of values were computed for each index.

## RESULTS

Tables 1-18 present the methodology and descriptive statistics for each anthropometric index.

## DISCUSSION

The findings of this study are presented in a descriptive format and can serve as a reference for interested personnel in the fields of human factors, clothing and uniform design, diving medicine, environmental physiology, naval diving operations, and epidemiology.

A large data bank of anthropometric measures on U.S. Navy divers is important and should be enlarged in future investigations. This information can be used in the design of diving suits and equipment. It can also characterize populations of naval divers on the basis of body build and limb dimension, and on the amounts of subcutaneous

fat at various body sites. This latter information can be used in epidemiologic studies which try to relate risk for certain diseases and occupational injuries to multiphasic health variables. Results from these studies can also be incorporated into the redefinition of new standards of physical qualification for Navy divers.

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TABLE 1

Weight

Subject is weighed while wearing only undershorts. The unit of measure is kilograms.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number 134	60
Mean value	81.2	Mean 80.0	83.9
Std. deviation	10.0	S.D. 9.5	10.5
Percentiles		Range 59.5-103.6	60.9-110.0
5th	65.9		
10th	69.1		
25th	73.6		
50th	79.5		
75th	88.2		
90th	95.5		
95th	100.0		

Table 2

Height

Subject stands erect, with heels together and head level. Height is measured as the vertical distance from the top of the head (vertex). The unit of measure is centimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number 134	60
Mean	178.3	Mean 178.5	177.9
Std. Deviation	6.6	S.D. 6.7	6.4
Percentiles		Range 162.4-193.1	159.1-190.0
5th	167.8		
10th	169.5		
25th	173.3		
50th	178.7		
75th	183.1		
90th	186.1		
95th	188.2		

TABLE 3

Functional Reach

Subject stands erect against a wall, with his scapulae touching the wall. His right arm is extended forward horizontally, with the tips of his thumb and index fingers pressed together. Functional reach is measured as the horizontal distance from the wall to the outer edge of the junction of the tips of the thumb and index fingers. The unit of measure is centimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number 134	60
Mean	80.1	Mean 80.2	80.0
Std. Deviation	4.4	S.D. 4.5	4.0
Percentiles		Range 71.0-92.0	70.1-90.0
5th	73.2		
10th	74.4		
25th	76.8		
50th	80.2		
75th	83.1		
90th	86.0		
95th	87.2		

TABLE 4

Sitting Height

Subject sits erect with head level and with his feet resting on the floor. The seat is adjusted so that his knees are bent at right angles. Sitting height is measured as the vertical distance from the sitting surface to the top of the head (vertex). The unit of measure is centimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number 134	60
Mean	92.6	Mean 92.6	92.5
Std. Deviation	3.7	S.D. 3.9	3.3
Percentiles		Range 80.4-102.8	82.2-97.9
5th	86.1		
10th	88.2		
25th	90.1		
50th	92.6		
75th	94.9		
90th	97.1		
95th	98.6		

TABLE 5

Chest Depth

Subject stands erect with his arms initially raised and then lowered after the anthropometer is in place under the right arm. The depth of the chest is measured at the level of the nipples during normal breathing. The unit of measure is centimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number	134
Mean	24.8	Mean	24.3
Std. Deviation	2.1	S.D.	1.9
Percentiles		Range	18.0-29.7
5th	21.7		21.4-31.5
10th	22.4		
25th	23.4		
50th	24.6		
75th	26.3		
90th	27.3		
95th	28.9		

TABLE 6

Chest Breadth

Subject stands erect with his arms initially raised and then lowered after the anthropometer is in place. The breadth of the chest is measured at the level of the nipples during normal breathing. The unit of measure is centimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	194	Number	134
Mean	34.3	Mean	34.1
Std. Deviation	2.5	S.D.	2.3
Percentiles		Range	23.5-40.0
5th	30.9		25.4-41.9
10th	31.6		
25th	32.8		
50th	34.3		
75th	35.8		
90th	37.5		
95th	38.5		

TABLE 7

Shoulders (Bideloid) Breadth

Subject sits erect with his arms bent to form right angles at the elbows and with his elbows held against the body. The maximum breadth across the shoulders is measured at the level of the bulges of the deltoid muscles in the upper arms. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	48.7	Mean	48.5	49.2
Std. Deviation	2.4	S.D.	2.3	2.5
Percentiles		Range	43.2-54.7	44.2-55.6
5th	45.0			
10th	45.7			
25th	47.0			
50th	48.5			
75th	50.1			
90th	52.1			
95th	52.7			

TABLE 8

Hand Length

Subject sits with his right hand and fingers extended and palm up. The length of the right hand is measured from the wrist crease to the tip of the middle finger. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	19.3	Mean	19.3	19.1
Std. Deviation	0.9	S.D.	0.8	0.9
Percentiles		Range	17.2-21.5	16.9-21.0
5th	17.8			
10th	18.3			
25th	18.7			
50th	19.2			
75th	19.9			
90th	20.4			
95th	20.6			

TABLE 9

Hand Breadth

Subject sits with his right hand and fingers extended and palm up. The breadth of the hand is measured at the level of the knuckles (distal ends of the metacarpal bones). The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	9.3	Mean	9.3	9.2
Std. Deviation	0.4	S.D.	0.4	0.4
Percentiles		Range	8.5-10.7	8.0-10.2
	5th			
	10th			
	25th			
	50th			
	75th			
	90th			
	95th			

TABLE 10

Foot Length

Subject stands erect with his weight evenly distributed on both feet. The maximum length of the right foot is measured from the back of the heel to the tip of the longest toe. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	27.1	Mean	27.2	26.9
Std. Deviation	1.3	S.D.	1.2	1.5
Percentiles		Range	24.3-29.9	20.1-29.5
	5th			
	10th			
	25th			
	50th			
	75th			
	90th			
	95th			

TABLE 11

Inspiratory Chest Circumference

Subject stands erect with his arms initially raised and then lowered after the tape is in place. The maximum horizontal circumference of the chest is measured at the level of the nipples at full inspiration. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	103.2	Mean	102.2	105.4
Std. Deviation	6.2	S.D.	6.0	6.2
Percentiles		Range	91.2-121.0	94.3-120.1
5th	94.0			
10th	95.7			
25th	99.0			
50th	102.6			
75th	107.3			
90th	111.2			
95th	113.8			

TABLE 12

Expiratory Chest Circumference

Subject stands erect with his arms initially raised and then lowered after the tape is in place. The maximum horizontal circumference of the chest is measured at the level of the nipples at full expiration. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	194	Number	134	60
Mean	96.7	Mean	95.4	99.4
Std. Deviation	6.2	S.D.	5.7	6.5
Percentiles		Range	82.2-110.7	84.9-116.6
5th	87.0			
10th	89.6			
25th	92.4			
50th	96.6			
75th	99.5			
90th	105.5			
95th	108.4			

TABLE 13

Waist Circumference

Subject stands erect with abdomen relaxed. The maximum horizontal circumference of the waist is measured at the level of the umbilicus. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	193	Number	134	59
Mean	88.5	Mean	86.4	93.4
Std. Deviation	8.5	S.D.	7.8	8.1
Percentiles		Range	71.2-106.8	75.5-110.0
5th	76.2			
10th	77.5			
25th	82.0			
50th	88.5			
75th	94.6			
90th	100.0			
95th	103.2			

TABLE 14

Vertical Trunk Circumference

Subject stands erect with his feet slightly apart. The vertical circumference of the trunk is measured with a steel tape passed through the crotch, to the right of the scrotum, and then over the midpoints of the right shoulder and right buttock. The unit of measure is centimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	193	Number	134	59
Mean	163.9	Mean	162.9	166.1
Std. Deviation	9.4	S.D.	9.8	7.9
Percentiles		Range	104.5-198.6	146.8-182.1
5th	151.0			
10th	153.0			
25th	159.2			
50th	163.5			
75th	169.2			
90th	174.5			
95th	178.2			

TABLE 15

Triceps Skinfold Thickness

The skinfold is picked up on the dorsum of the right arm, at a point midway between the acromial process of the scapula and the tip of the olecranon. Measurement is made with the forearm flexed to 90° and the arm pendant. The unit of measure is millimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	153	Number	104	49
Mean	17.7	Mean	17.2	18.7
Std. Deviation	7.8	S.D.	7.9	7.5
Percentiles		Range	3-35	4-33
5th	7			
10th	8			
25th	12			
50th	17			
75th	23			
90th	29			
95th	30			

TABLE 16

Subscapular Skinfold Thickness

The skinfold is picked up under the angle of the right scapula. The fold is pointing slightly downward and outward. The unit of measure is millimeters.

Total Cohort		Age Strata		
		20-30	31-42	
Number	153	Number	104	49
Mean	20.1	Mean	18.2	24.0
Std. Deviation	9.0	S.D.	8.3	9.2
Percentiles		Range	6-42	8-46
5th	9			
10th	10			
25th	13			
50th	18			
75th	28			
90th	33			
95th	36			



TABLE 17

Suprailiac Skinfold Thickness

The skinfold is picked up one centimeter above and two centimeters medial to the right anterior superior iliac spine. The unit of measure is millimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	153	Number	104
Mean	24.3	Mean	23.1
Std. Deviation	11.5	S.D.	11.6
Percentiles		Range	5-50
5th	7		7-46
10th	9		
25th	14		
50th	23		
75th	34		
90th	41		
95th	45		

TABLE 18

Abdominal Skinfold Thickness

The skinfold is picked up at the level of the umbilicus and 2.5 centimeters to the right of it. The unit of measure is millimeters.

Total Cohort		Age Strata	
		20-30	31-42
Number	153	Number	104
Mean	24.8	Mean	22.0
Std. Deviation	13.2	S.D.	12.1
Percentiles		Range	4-58
5th	8		8-54
10th	9		
25th	14		
50th	22		
75th	34		
90th	45		
95th	48		

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divers, these data have application as a reference source for personnel working in diving suit and equipment design, diving operations, human factors research, diving medicine and epidemiology.

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